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SUBSTITUTES FOR SUCROSE IN CURING MEATS.

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CONTENTS.

	Page.
Quantity of sugar used in curing meats	1
Function of sugar in curing meat	2
Substitutes for sugar	2
Refiners' sirup	2
Corn sugars	3
Experimental work	4
General plan	4
Experiments with pork hams	4
Experimental work—Continued.	
Experiments with sweet-pickle bacon	12
Experiments with box-cured bacon	19
Experiments with beef hams	23
General summary	28

QUANTITY OF SUGAR USED IN CURING MEATS.

Sugar is used extensively in the curing of meats in this country. In 1917, 15,924,009 pounds of sugar as such and 1,712,008 pounds in the form of sirup, or a total of 17,636,017 pounds, was used in curing meats in pickle in Government-inspected establishments. In addition, a considerable quantity of sugar was used in curing meats in the dry way, so that the total quantity of sugar used in curing meats probably amounted to about 20,000,000 pounds. This estimate does not include the amount of sugar used in curing meats on the farm, for which there are no data available.

At the time the sugar shortage developed in this country during the war, an investigation was started to ascertain how the greatest economy in the use of sugar in curing meats could be effected. Several methods appeared feasible but the use of certain sugar substistutes appeared to be the most practicable one. A series of carefully controlled experiments in the curing of several classes of meats with a number of sugar substitutes and with cane sugar was carried on in three large and one small meat-packing establishment. This investigation was completed a short time before the signing of the armistice, and while the war-time need for the information has passed, yet it is believed that the results of these experiments may be of present value.

FUNCTION OF SUGAR IN CURING MEAT.

Sugar is used in curing meat chiefly on account of its effect upon the quality of the product. "Sugar-cured" hams and bacon are supposed to be of superior quality. A very large proportion of the fancy hams and bacon on the American market has been cured with the use of sugar or sirup.

Sugar is not used in curing meat on account of its preservative action; in fact, it is probable that the quantity of sugar ordinarily used exerts but very little, if any, preservative action. Meat can be cured in entire safety without the use of any sugar, and large quantities are so cured.

SUBSTITUTES FOR SUGAR.

The sugar generally used in curing meats is sucrose in the form of granulated, clarified, or plantation-raw sugar. In addition, a considerable quantity of second-grade refiners' sirup is also used. This grade of refiners' sirup is not suited to replace granulated sugar in the household.

The essential requirements for sugar substitutes used in curing meats are: (1) The cured meat should be of as high quality as that cured with sucrose; (2) there should be practically no spoilage of meat during the curing process; (3) the substitute should be available in sufficient quantities and at a price comparable with that of sucrose. The following products were investigated as to their suitability for the purpose.

REFINERS' SIRUP.

Refiners' sirup, second grade, is a dark-colored, strong-flavored product resulting from the refining of cane sugar. It is variable in composition and quality and is usually purchased on specifications as to sugar and ash content. The total domestic production of first- and second-grade refiners' sirup in 1918 is estimated by one of the large sugar-refining companies to have been 345,000,000 pounds, which is equivalent to approximately 210,000,000 pounds of sugar. Data on the production of second-grade sirup could not be obtained. It appears that the total supply of refiners' sirup is about ten times greater than the amount required to meet the sugar needs of the meat-packing industry. First-grade refiners' sirup is much higher in price than the second-grade product, and for that reason is ordinarily not used in curing meats, and if the production of second-grade sirup is estimated as half the total production, then the lower-grade sirup would supply approximately five times as much sugar as is needed in curing meats. However, the total supply of this grade of sirup is not available for the purpose.

There is considerable difference of opinion among meat-packing establishments as to the value of refiners' sirup for use in curing meats. A considerable number of establishments use sirup exclusively in curing pork products in pickle, with very satisfactory results; on the other hand, a large proportion of the meat-packing establishments do not use sirup at all. According to the data previously cited regarding the use of sugar and sirup in curing meats in pickle during 1917, it appears that approximately 10 parts of sugar as such were used as compared with 1 part of sugar in the form of sirup.

CORN SUGARS.

There are at least three grades of corn sugar, besides glucose sirup, as follows:

1. Dextrose is a white powder resembling confectioners' sugar in appearance. It is mildly sweet and dissolves readily in cold water. It is nearly pure dextrose and contains only a small percentage of moisture.

2. Cerelose is the trade name for a second-grade corn sugar. It is sold in the form of very small, light-brown globules of a mildly sweet flavor. It dissolves fairly readily in cold water. It is supposed to contain about 86 per cent dextrose, 10 per cent moisture, and 0.6 per cent ash. This product is used extensively as a substitute for sugar. At the time of the acute sugar shortage during the war, the supply of this product was not nearly equal to the demand.

3. Seventy per cent corn sugar is a crude product marketed in the form of brown lumps of various sizes. It dissolves slowly in cold water and fairly readily in hot water, yielding a brown-colored, mildly sweet sirup. The manufacturer states that this product contains approximately 70 per cent dextrose, 20 per cent moisture, 0.6 per cent ash, and the remainder dextrin, etc. This product is ordinarily available in large quantities.

Glucose sirup was not considered on account of its relatively high dextrin and low sugar content, and because it was a much more expensive source of dextrose than the above-named corn sugars.

The following table shows the composition of the corn sugars and the sirups used in the experiments:

TABLE 1.—*Composition of corn sugars and refiners' sirup.*

Product.	Moisture.	Ash.	Sucrose.	Reducing sugar.	Dextrose.	Not determined.
Corn sugars:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Dextrose	2.14	0.17	.....	.....	96.65	1.04
Cerelose	9.30	.65	.....	.....	84.73	5.32
70 per cent corn sugar	11.56	.65	.....	.....	77.75	10.04
Refiners' sirup:						
(a)	20.44	3.12	40.29	24.25	.....	11.90
(b)	20.12	4.42	40.95	22.46	.....	12.05
(c)	22.60	5.10	34.49	26.04	.....	11.77

EXPERIMENTAL WORK.

GENERAL PLAN.

Four series of experiments were carried out, one each with hams, sweet-pickle bacon, dry-cure bacon, and beef hams. These experiments were carried on in one small but modern meat-packing establishment and in three large establishments, which will be designated as X, A, B, and C, respectively. The general plan of the experiments was the same for each establishment. At each plant the work was conducted as nearly as possible in the same manner as was regularly followed in curing the several kinds of meat under investigation. In each experiment one package of meat was cured according to the regular practice in the establishment, while to each of the other packages an equivalent amount of each of the sugars under investigation was added in place of the sugar regularly used. In other respects all the packages at one establishment were handled in exactly the same manner.

EXPERIMENTS WITH PORK HAMS.

These experiments were carried on at each of the four establishments, but the one conducted at establishment X was of a preliminary nature and not so extensive as those carried on at the other plants.

PRELIMINARY EXPERIMENT AT ESTABLISHMENT X.

Three tierces of hams were cured at establishment X—one without sugar, one with granulated sugar, and one with cerelose. The chilled hams were packed in tierces, as follows: Tierce 1, a mixture of 8¼ pounds of salt and 7 ounces of sodium nitrate was sprinkled over the faces of the hams as packed; tierce 2, the same quantities of salt and sodium nitrate, and in addition 4½ pounds of granulated sugar were sprinkled over the faces of the hams in the same way; tierce 3 was packed in similar manner except that a like quantity of cerelose was substituted for the granulated sugar. The tierces were held 48 hours in a curing cellar at 35°–37° F. and were then headed, filled with 80° plain brine and held at the temperature stated until cured. The tierces were rolled on the fifth, fifteenth, and thirtieth days after packing. The cured hams were weighed, inspected for soundness, soaked 7½ hours in water to remove excess salt, and smoked 11½ hours. Two smoked hams from each tierce were selected for test purposes. A brief record of the experiment appears in Table 2.

TABLE 2.—*Record of preliminary ham-curing experiment, establishment X.*

Item.	Tierce 1, no sugar.	Tierce 2, granulated sugar.	Tierce 3, cerelose.
Number of hams	33	27	30
Curing period.....days	39	39	39
Weight of cured hams.....pounds	362	354	348
Condition of cured hans	Normal.	Normal.	Normal.

QUALITY OF THE CURED HAMS.

In this and subsequent tests the quality of the hams was judged from the appearance of the freshly cut surfaces of the hams and by the appearance and palatability of the fried product. Two hams from each lot were used for the purpose. The hams were tested by 11 persons, some of whom cooked and tested slices of ham in their homes while others attended a test conducted in the laboratory. The slices of ham were always fried in a clean pan and never in the drippings remaining after frying slices of another lot of hams. Those who tested the hams in their homes were instructed to observe similar precautions. A report of the test on the hams is presented in Table 3.

TABLE 3.—*Quality of hams (preliminary experiment at establishment X).*

Judge.	Tierce 1, no sugar.	Tierce 2, granulated sugar.	Tierce 3, cerelose.	Judge.	Tierce 1, no sugar.	Tierce 2, granulated sugar.	Tierce 3, cerelose.
	Points.	*Points.*	*Points.*		*Points.*	*Points.*	*Points.*
A	2	2	2	H	3	1	2
B	1	2	3	I	3	1	2
C	1	3	2	J	1	2½	2½
D	1	3	2	K	3	2	1
E	1	2	3				
F	1	2½	2½	Total	20	22	24
G	3	1	2				

Basis for scoring: First choice, 3 points; second choice, 2 points, third choice, 1 point. When no choice was indicated the samples were scored alike. The result of this test indicates that the hams cured with cerelose were considered to be slightly the best in quality, followed closely in turn by those cured with granulated sugar and with no sugar. There was really very little difference in the quality of the three lots of hams. It was noted, however, that the hams cured with sugar browned more readily on frying than those cured without sugar.

EXPERIMENTS AT ESTABLISHMENTS A, B, AND C.

PLAN OF WORK.

Six tierces of hams were cured at establishment A and five each at establishments B and C. The chilled hams were first pumped in the body and shank with 100° brine containing sodium nitrate and were then packed in tierces, which were finally filled with pickle. At each establishment the pickles for the several tierces were made up according to the same formula except as regards the kind of sugar used. It may be noted here that raw cane sugar was being used regularly at the time in curing this class of hams at establishments A and C and refiners' sirup at establishment B. At establishments A and B the tierces of hams were stored at a temperature approximately 36°–37° F., and at establishment C they were stored at a temperature of 40° F. The tierces were rolled on the fifth, fifteenth, and thirtieth days after packing.

At establishment A the cured hams were soaked 2¾ hours in water at 70° F. and were smoked 30 hours at a temperature approximating 130°–135° F. At establishment B the cured hams were soaked 2 hours and 20 minutes in water at 70° F. and were smoked 18 hours at 100° F. At establishment C the cured hams were soaked 3 hours in water 60° F. and were smoked 16 hours at 125° F.

Each lot of smoked hams was carefully inspected for soundness by a Government inspector. Two sound smoked hams were selected from each lot at each establishment for test purposes, except from one tierce at establishment B, which had been mislaid.

A record of the experiments is given in Table 4.

TABLE 4.—*Record of ham-curing experiments at establishments A, B, and C.*

ESTABLISHMENT A.

Item.	Tierce 1, granulated sugar.	Tierce 2, dextrose.	Tierce 3, cerelose.	Tierce 4, 70 per cent corn sugar.	Tierce 5, refiners' sirup.	Tierce 6, raw sugar.
Number of hams	32	31	31	32	31	31
Curing period.....days..	54	54	54	54	54	54
Weight of green hams.....pounds..	300	300	300	300	300	300
Weight of cured hams.....do....	327	328	328	324	320	329
Gain in weight.....do....	27	28	28	24	20	29
Quantity of pickle.....gallons..	13	14.5	16	16.75	17	15.5
Condition of smoked hams	Normal.	Normal.	1 light shank sour.	Normal.	Normal.	1 shank sour.

ESTABLISHMENT B.

Number of hams	28	28	28	28	28	.....
Curing period.....days..	45	45	45	45	45	.....
Weight of green hams.....pounds..	290	290	290	290	290	.....
Weight of cured hams.....do....	322	Tierce lost.	318	322	322	.....
Gain in weight.....do....	32	.....	28	32	32	.....
Quantity of pickle.....gallons..	18	18	16½	16¼	18¾	.....
Condition of smoked hams	Normal.	.....	Normal.	1 light shank sour.	Normal.	.....

TABLE 4.—*Record of ham-curing experiments, etc.*—Continued.

ESTABLISHMENT C.

Item.	Tierce 1, granulated sugar.	Tierce 2, dextrose.	Tierce 3, cerelose.	Tierce 4, 79 per cent corn sugar.	Tierce 5, refiners' sirup.	Tierce 6, raw sugar.
Number of hams	20	20	20	20	20	.....
Curing period.....days..	55	55	55	55	55	.....
Weight of green hams.....pounds..	280	280	280	280	280	.....
Weight of cured hams.....do....	307	303	307	310	300	.....
Gain in weight.....do....	27	23	27	30	20	.....
Quantity of pickle.....gallons..	17	17	17	17	17	.....
Condition of smoked hams.....	Normal.	1 light aitchbone sour.	1 light shank sour.	Normal.	Normal.	.....

COMPOSITION OF PICKLE.

Table 5 indicates the composition of the new and old pickle from each tierce and of the pickle used in pumping the hams.

TABLE 5.—*Composition of new and old ham pickles at establishments A, B, and C.*

ESTABLISHMENT A.

Tierce No.	Age of pickle.	Kind of sugar.	Specific gravity at 20° C.	Salometer reading at 20° C.	Sodium chlorid.	Sodium nitrate.	Total sugar.
	Days.			*Degrees.*	*Per cent.*	*Per cent.*	*Per cent.*
1	New.	Granulated.....	1.144	72	16.15	0.57	3.92
1	54	.....do.....	1.095	49	9.03	.35	2.68
2	New.	Dextrose.....	1.144	72	16.26	.51	3.74
2	54	.....do.....	1.095	49	9.88	.42	2.48
3	New.	Cerelose.....	1.146	73	16.54	.53	3.62
3	54	.....do.....	1.094	48	10.13	.33	2.46
4	New.	70 per cent corn sugar.....	1.147	74	15.61	.57	4.39
4	54	.....do.....	1.095	49	9.97	.36	3.03
5	New.	Refiners' sirup.....	1.148	74	15.73	.57	4.16
5	54	.....do.....	1.093	48	9.29	.44	2.87
6	New.	Raw sugar.....	1.144	72	16.15	.53	3.84
6	54	.....do.....	1.092	47	9.62	.31	2.71
Pumping pickle.	New.	None.....	1.221	.....	23.10	6.49	.....

ESTABLISHMENT B.

1	New.	Granulated.....	1.138	70	16.07	0.29	2.80
1	45	.....do.....	1.096	49	10.84	.25	2.19
2	New.	Dextrose.....	1.138	70	16.50	.29	2.55
3	New.	Cerelose.....	1.138	70	16.50	.29	2.53
3	45	.....do.....	1.095	49	10.76	.22	1.87
4	New.	70 per cent corn sugar.....	1.138	70	16.18	.36	2.65
4	45	.....do.....	1.095	49	10.58	.27	2.05
5	New.	Refiners' sirup.....	1.142	72	16.18	.31	2.78
5	45	.....do.....	1.098	50	10.76	.24	2.08
Pumping pickle.	New.	None.....	1.210	.....	24.64	2.87	.....

ESTABLISHMENT C.

1	New.	Granulated.....	1.151	76	17.67	0.22	2.60
1	55	.....do.....	1.104	53	11.70	.08	2.05
2	New.	Dextrose.....	1.150	76	17.27	.24	3.17
2	55	.....do.....	1.100	51	11.19	.13	2.24
3	New.	Cerelose.....	1.150	76	17.17	.19	2.82
3	55	.....do.....	1.103	53	11.56	.06	2.15
4	New.	70 per cent corn sugar.....	1.149	75	17.79	.23	3.16
4	55	.....do.....	1.103	53	11.30	.19	1.68
5	New.	Refiners' sirup.....	1.152	76	17.24	.23	3.14
5	55	.....do.....	1.097	49	10.31	.08	2.25
Pumping pickle.	New.	None.....	1.213	.....	25.32	2.19	.....

Table 6 shows the relative quantities of curing materials in the old pickle from each tierce, based upon 100 parts of each curing material in the new pickle.

TABLE 6.—*Relative composition of new and old ham pickles at establishments A, B, and C.*

ESTABLISHMENT A.

Constituent.	Age of pickle.	Tierce 1, granulated sugar.	Tierce 2, dextrose.	Tierce 3, cerelose.	Tierce 4, 70 per cent corn sugar.	Tierce 5, refiners' sirup.	Tierce 6, raw sugar.
	Days.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Sodium chlorid	New.	100.00	100.00	100.00	100.00	100.00	100.00
Do	54	55.91	60.39	61.25	61.95	59.06	59.57
Sodium nitrate	New.	100.00	100.00	100.00	100.00	100.00	100.00
Do	54	61.58	83.35	62.26	63.16	77.19	58.49
Total sugar	New.	100.00	100.00	100.00	100.00	100.00	100.00
Do	54	68.37	66.31	67.96	69.02	68.99	70.57

ESTABLISHMENT B.

Sodium chlorid	New.	100.00	100.00	100.00	100.00	100.00	.....
Do	45	67.45	.....	65.21	65.39	66.44	.....
Sodium nitrate	New.	100.00	100.00	100.00	100.00	100.00	.....
Do	45	86.21	.....	75.86	75.00	79.35	.....
Total sugar	New.	100.00	100.00	100.00	100.00	100.00	.....
Do	45	78.21	.....	73.91	77.36	74.82	.....

ESTABLISHMENT C.

Sodium chlorid	New.	100.00	100.00	100.00	100.00	100.00	.....
Do	55	66.21	64.79	67.32	63.52	59.80	.....
Sodium nitrate	New.	100.00	100.00	100.00	100.00	100.00	.....
Do	55	36.36	54.17	31.58	82.61	34.78	.....
Total sugar	New.	100.00	100.00	100.00	100.00	100.00	.....
Do	55	78.85	70.66	76.24	53.23	71.66	.....

These data indicate no great differences in the sugar content of the old pickle from the different tierces. There are considerable variations in the sodium-nitrate and sodium-chlorid contents of some of the pickles, but it is doubtful if they have any special significance. Attention is called to the fact that on the average the old pickle from the three establishments contains 63.38 parts sodium chlorid, 64.85 parts sodium nitrate, and 71.57 parts sugar, as compared with 100 parts present in the new pickle. The waste of curing materials occasioned by throwing away the old pickle from cured hams is apparent.

COMPOSITION OF THE HAMS.

Table 7 shows the composition of the hams. Analyses were made of the lean portion of a slice cut from the thickest part of each of two hams from each lot. While there is more or less variation in the composition of the several lots of hams, the data do not appear to have any special significance.

TABLE 7.—*Composition of hams at establishments A, B, and C.*

ESTABLISHMENT A.

Constituent.	Tierce 1, granulated sugar.	Tierce 2, dextrose.	Tierce 3, cerelose.	Tierce 4, 70 per cent corn sugar.	Tierce 5, refiners' sirup.	Tierce 6, raw sugar.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	49.28	54.42	54.97	50.10	54.38	55.68
Sodium chlorid	3.60	4.26	4.41	3.91	4.27	4.56
Sodium nitrate	.19	.25	.27	.23	.29	.25
Total sugar	.67	.36	.58	.59	.39	.36

ESTABLISHMENT B.

Moisture	49.90	.....	56.27	52.95	53.11	.....
Sodium chlorid	4.52	.....	5.27	4.59	5.01	.....
Sodium nitrate	.11	.....	.10	.11	.09	.....
Total sugar	.36	.....	.50	.42	.53	.....

ESTABLISHMENT C.

Moisture	45.52	45.17	51.33	53.30	42.20	.....
Sodium chlorid	4.96	4.33	5.80	5.15	4.40	.....
Sodium nitrate	.07	.06	.06	.07	.06	.....
Total sugar	.36	.50	.56	.42	.48	.....

QUALITY OF THE CURED HAMS.

The quality of the several lots of hams was judged in the same manner as described under establishment X, except that all the tests were made in the laboratory. Two hams from each tierce were tested for quality. In Table 8 is presented a report on the quality of the several lots of hams.

At establishment A the hams cured with refiners' sirup were considered to be of the poorest quality, and yet some widely distributed well-known brands of hams are cured with this grade of sirup. The opinion was very generally expressed by the judges that all the hams were of high grade and that there was really very little difference in the quality of the several lots.

A similar test of the quality of each of the several lots of hams in this experiment was carried on by the establishment in which the curing test was made, but with considerably varying results. However, by adding together the total number of points scored by each lot of hams in the two tests an average estimate of the relative quantity of the several lots is obtained, as follows: Tierce 1, granulated sugar, 76 points; tierce 6, raw sugar, 73 points; tierce 2, dextrose, 68 points; tierce 3, cerelose, 63 points; tierce, 5; refiners' sirup, 50 points; and tierce 4, 70 per cent corn sugar, 46 points.

At establishment B the basis for scoring was: First choice, 4 points; second choice, 3 points, etc. As before stated the hams in tierce 2 had been mislaid and were not scored. The results indicate that the

hams cured with 70 per cent corn sugar were of the highest quality, closely followed, in turn, by those cured with cerelose and granulated sugar, while those cured with refiners' sirup were considered to be of appreciably lower quality. Tierce 5, in which refiners' sirup was used as the source of sugar, was cured according to the regular practice at this establishment, except that the hams were cured in a tierce instead of in a large, open vat.

At establishment C the basis of scoring ranged from 5 to 1, as compared with 4 to 1 at establishment B, and 6 to 1 at establishment A. The data presented in Table 8 indicate that at establishment C there was comparatively little difference in the quality of the three lots of hams cured with granulated sugar, dextrose, and refiners' sirup. The hams cured with cerelose were of only slightly lower quality, and those cured with 70 per cent corn sugar were considered to be of poorer quality than the others, but all lots were of good quality.

TABLE 8.—*Quality of hams at establishments A, B, and C.*

ESTABLISHMENT A (OFFICIAL TEST).

Judge.	Tierce 1, granulated sugar.	Tierce 2, dextrose.	Tierce 3, cerelose.	Tierce 4, 70 per cent corn sugar.	Tierce 5, refiners' sirup.	Tierce 6, raw sugar.
	Points.	*Points.*	*Points.*	*Points.*	*Points.*	*Points.*
A	6	3	5	1	2	4
B	4	2	6	1	5	3
C	5	2	6	1	4	3
D	5	4	6	3	2	1
E	5	3	1	2	4	6
F	5	4	2	3	1	6
G	4	6	2	5	1	3
H	6	3	4	5	1	2
I	6	2	5	3	1	4
Total	46	29	37	24	21	32

ESTABLISHMENT A (PLANT TEST).

M	5	6	4	1	2	3
N	1	2	3	6	4	5
O	2	3	6	1	4	5
P	5	2	3	4	1	6
Q	3	4	2	1	5	6
R	1	6	2	3	4	5
S	4	6	2	3	5	1
T	6	5	2	1	3	4
U	3	5	4	2	1	6
Total	30	39	28	22	29	41

ESTABLISHMENT B.

A	4	.....	2	3	1	.....
B	2	.....	3	4	1	.....
C	2	.....	4	3	1	.....
D	1	.....	3	4	2	.....
E	4	.....	2	3	1	.....
F	4	.....	3	2	1	.....
G	1	.....	3	4	2	.....
H	2	.....	4	3	1	.....
Total	20	.....	24	26	10	.....

TABLE 8.—*Quality of hams at establishments A, B, and C*—Continued.

ESTABLISHMENT C.

Judge.	Tierce 1, granulated sugar.	Tierce 2, dextrose.	Tierce 3, cerelose.	Tierce 4, 70 per cent corn sugar.	Tierce 5, refiners' sirup.	Tierce 6, raw sugar.
	Points.	*Points.*	*Points.*	*Points.*	*Points.*	*Points.*
A	5	4	3	1	2	.....
B	1	3	5	2	4	.....
C	1	3	2	5	4	.....
D	5	2	3	1	4	.....
E	1	4	5	2	3	.....
F	5	3	1	2	4	.....
G	2	4	3	1	5	.....
H	5	3	1	4	2	.....
I	5	1	2	4	3	.....
J	4	5	3	1	2	.....
Total	34	32	28	23	33	.....

SUMMARY OF RESULTS OF HAM-CURING EXPERIMENTS.

1. Eighteen tierces of hams were cured at four establishments.

2. The extent of the absorption of the curing materials by the hams does not bear any relation to the kind of sugar used.

3. As an average of the results obtained at establishments A, B, and C it was found that the old pickle from the cured hams contained 63.4 per cent of the sodium chlorid, 64.83 per cent of the sodium nitrate, and 71.56 per cent of the sugar present in the new pickle. From the standpoint of economy the importance of making use of the old pickle, on account of the curing materials which it contains, is evident.

4. Five sour hams, three of which were classed as light shank sours, one of a light aitchbone sour, and one a shank sour, were found in a total of 518 hams cured. One sour ham was found in a tierce cured with dextrose, two in tierces cured with cerelose, one in a tierce cured with 70 per cent corn sugar, and one in a tierce cured with raw sugar. These data do not necessarily indicate the percentage of sour hams which might be expected in the practical curing of hams with the several sugars on a large scale. Such information can be obtained only by extended practical use of the sugars.

5. The average relative quality of the hams cured with the several sugars at the four establishments can not be indicated with a high degree of accuracy, since not all the sugars were used at each establishment. However, a careful consideration of the reports on the quality of the hams cured at each plant indicates that the hams should be ranked in approximately the following order, according to the kind of sugar used: First, granulated sugar; second, raw sugar; third, cerelose; fourth, dextrose; fifth, refiners' sirup; sixth, 70 per cent corn sugar. There really was very little difference in the quality of the first five lots of hams, and even the sixth lot, cured with 70

per cent corn sugar, was considered to be of good quality. In fact, in the experiment carried on at establishment B the hams cured with this sugar ranked first.

EXPERIMENTS WITH SWEET-PICKLE BACON.

Experiments with sweet-pickle bacon were carried on at each of the four establishments, but, as with the hams, the one at establishment X was of a preliminary nature. In all, 19 tierces of bellies were cured.

PRELIMINARY EXPERIMENT AT ESTABLISHMENT X.

Three tierces of bellies were cured at establishment X, one with granulated sugar, one with cerelose, and one without sugar. The chilled bellies were packed in tierces as follows: Tierce 1: Sixty-one bellies were packed together with 8 ounces of sodium nitrate, 10 pounds of salt, and 4½ pounds of granulated sugar, the curing materials being sprinkled over the faces of the bellies. Tierce 2: Fifty-five bellies were packed with the above quantities of salt and sodium nitrate and with 4½ pounds of cerelose. Tierce 3: Fifty-five bellies were packed with the same quantities of salt and sodium nitrate, but without sugar. The tierces were held 48 hours in a curing cellar at 35°–37° F., then filled with plain 70° brine, and held at the same temperature until cured. The tierces were rolled on the fifth, fifteenth, and thirtieth days after packing. The cured bellies were inspected for soundness, soaked 5 hours in water, and smoked 13 hours. No unsound bellies were found. Two smoked bellies were selected from each lot for test purposes. In Table 9 is presented a brief record of the experiment.

TABLE 9.—*Record of preliminary sweet-pickle bacon experiment, establishment X.*

Item.	Tierce 1, granulated sugar.	Tierce 2, cerelose.	Tierce 3, no sugar.
Number of bellies	61	55	55
Curing period.....days..	33	33	33
Weight of cured bellies.....pounds..	410	425	415
Condition of cured bellies	Normal.	Normal.	Normal.

QUALITY OF THE SWEET-PICKLE BACON.

The relative quality of the three lots of bacon was judged upon the basis of the appearance of the freshly cut surface of the bacon and upon the appearance, texture, and palatability of the fried or broiled product. The three lots of bacon were tested by 12 individuals, 6 of whom determined the quality of the bacon in their homes, while the other 6 attended a test held in the laboratory. In

this and subsequent tests made in this laboratory each lot of bacon was fried in a clean frying pan over a low flame and in as nearly the same manner as possible as each of the other lots. A summary of the reports of the judges is presented in Table 10.

TABLE 10.—*Quality of sweet-pickle bacon (preliminary experiment at establishment X.)*

Judge.	Tierce 1, granulated sugar.	Tierce 2, cerelose.	Tierce 3, no sugar.
	Points.	*Points.*	*Points.*
A	2	3	1
B	3	2	1
C	2	3	1
D	1	3	2
E	3	2	1
F	3	1½	1½
G	1½	1½	3
H	3	1	2
I	3	1	2
J	3	2	1
K	2	3	1
L	2	3	1
Total	28½	26	17½

Basis for scoring: First choice, 3 points; second choice, 2 points; third choice, 1 point. The result of the test indicates that there was very little difference in the quality of the bacon cured with granulated sugar as compared with that cured with cerelose, but that the bacon cured without sugar was of appreciably lower quality. This lot of bacon did not brown on frying and the flavor was distinctly inferior to that of the two other lots.

EXPERIMENTS AT ESTABLISHMENTS A, B, AND C.

PLAN OF WORK.

Six tierces of bellies were cured at establishment A, and 5 each at establishments B and C.

At each establishment the chilled bellies were packed in tierces which were then filled with pickles made up according to the same formula except as regards the kind of sugar used. Raw sugar was being used at the time in curing this class of meat at establishment A, and refiners' sirup at establishment B. The tierces were stored during the curing period at a temperature approximating 36°–37° F. at establishments A and B, and at a temperature of 40° F. at establishment C. The tierces were rolled on the fifth and fifteenth days after packing.

At establishment A the cured bellies were soaked 1¼ hours in water at 70° F. and were smoked 30 hours at a temperature of 130°–135° F. At establishment B the bellies were due to be cured in 30 days but by a mistake were left in cure 48 days. The cured bellies were soaked

2 hours and 20 minutes in water at 70° F. and were smoked 18 hours at a temperature approximating 100° F. At establishment C the cured bellies were soaked 1½ hours in water at 60° F. and were smoked 18 hours at 120°–130° F. The smoked bellies were inspected for soundness by a Government inspector. A record of the experiments is shown in Table 11.

TABLE 11.—*Record of sweet-pickle bacon experiments at establishments A, B, and C.*

ESTABLISHMENT A.

Item.	Tierce 1, granulated sugar.	Tierce 2, dextrose.	Tierce 3, cerelose.	Tierce 4, 70 per cent corn sugar.	Tierce 5, refiners' sirup.	Tierce 6, raw sugar.
Number of bellies	34	34	33	35	34	35
Curing period.....days	26	26	26	26	26	26
Weight of green bellies.....pounds	300	300	300	300	300	300
Weight of cured bellies.....do	336	330	331	330	332	331
Gain in weight.....do	36	30	31	30	32	31
Quantity of pickle.....gallons	17	16½	18½	16	14	16
Condition of smoked bellies	Normal.	Normal.	Normal.	Normal.	Normal.	Normal.

ESTABLISHMENT B.

Number of bellies	24	26	26	25	26	.....
Curing period.....days	48	48	48	48	48	.....
Weight of green bellies.....pounds	280	280	280	280	280	.....
Weight of cured bellies.....do	330	328	320	328	328	.....
Gain in weight.....do	50	48	40	48	48	.....
Quantity of pickle.....gallons	17	20	17½	18	18	.....
Condition of smoked bellies	Normal.	Normal.	Normal.	Normal.	Normal.	.....

ESTABLISHMENT C.

Number of bellies	26	26	26	26	26	.....
Curing period.....days	34	34	34	34	34	.....
Weight of green bellies.....pounds	280	280	280	280	280	.....
Weight of cured bellies.....do	310	310	305	305	305	.....
Gain in weight.....do	30	30	25	25	25	.....
Quantity of pickle.....gallons	17	17	17	17	17	.....
Condition of smoked bellies	Normal.	Normal.	Normal.	Normal.	Normal.	.....

COMPOSITION OF PICKLE.

The composition of the new and old pickle from each tierce of bellies is shown in Table 12.

TABLE 12.—*Composition of new and old bacon pickle.*

ESTABLISHMENT A.

Tierce No.	Age of pickle.	Kind of sugar.	Specific gravity at 20° C.	Salometer reading at 20° C.	Sodium chlorid.	Sodium nitrate.	Total sugar.
	Days.			*Degrees.*	*Per cent.*	*Per cent.*	*Per cent.*
1	New.	Granulated	1.139	70	16.70	0.49	1.78
1	26	.....do	1.090	46	10.21	.29	1.36
2	New.	Dextrose	1.139	70	16.70	.53	1.76
2	26	.....do	1.090	46	10.31	.36	1.22
3	New.	Cerelose	1.141	71	16.67	.54	1.71
3	26	.....do	1.094	48	10.75	.36	1.20
4	New.	70 per cent corn sugar	1.136	68	16.40	.53	1.87
4	26	.....do	1.090	46	10.04	.34	1.32
5	New.	Refiners' sirup	1.138	69	16.57	.53	1.77
5	26	.....do	1.093	48	10.32	.36	1.32
6	New.	Raw	1.137	69	16.80	.53	1.71
6	26	.....do	1.090	46	10.62	.36	1.33

TABLE 12.—*Composition of new and old bacon pickle*—Continued.

ESTABLISHMENT B.

Tierce No.	Age of pickle.	Kind of sugar.	Specific gravity at 20° C.	Salometer reading at 20° C.	Sodium chlorid.	Sodium nitrate.	Total sugar.
	Days.			*Degrees.*	*Per cent.*	*Per cent.*	*Per cent.*
1	New.	Granulated	1.152	76	18.72	0.29	1.44
1	45	do	1.110	57	13.12	.13	1.13
2	New.	Dextrose	1.152	76	18.72	.44	1.45
2	45	do	1.111	57	13.40	.26	1.25
3	New.	Cerelose	1.156	78	19.43	.26	1.37
3	45	do	1.116	59	14.18	.20	.90
4	New.	70 per cent corn sugar	1.152	76	18.55	.26	1.52
4	45	do	1.110	57	13.07	.17	1.11
5	New.	Refiners' sirup	1.156	78	18.17	.24	2.45
5	45	do			12.81	.19	1.87

ESTABLISHMENT C.

1	New.	Granulated	1.140	70	17.42	0.24	0.86
1	27	do	1.105	54	9.65		
2	New.	Dextrose	1.139	70	17.44	.23	.82
2	27	do	1.098	50	9.52		.65
3	New.	Cerelose	1.139	70	17.46	.21	.81
3	27	do	1.097	49	9.52	.17	.64
4	New.	70 per cent corn sugar	1.140	70	17.47	.22	.84
4	27	do	1.099	50	9.61		.61
5	New.	Refiners' sirup	1.142	72	17.65	.24	.89
5	27	do	1.101	51	9.87		.72

Table 13 shows the relative composition of the new and old pickle from each tierce, based upon 100 parts of each curing material in the new pickle. The data from establishment A indicate comparatively small differences in the relative composition of the old pickle from the several tierces as compared with the composition of the new pickle. The old pickles from the tierces cured with corn sugar contain slightly less sugar than those from the tierces cured with cane sugars. The data indicate that on the average the old pickle contains 62.59 per cent of the salt, 65.62 per cent of the sodium nitrate, and 73.14 per cent of the sugar originally present in the new pickle. At establishment B there are considerable differences in the relative nitrate and sugar contents of the old pickles from several of the tierces, but the significance of these variations is not apparent. The data at this establishment indicate that on the average 71.12 per cent of the salt, 65.08 per cent of the sodium nitrate, and 75.96 per cent of the sugar originally present in the new pickle were present in the old pickle from the cured bacon.

An average of the data at establishment C indicates that 55 per cent of the salt and 77.39 per cent of the sugar originally present in the new pickle were found in the old pickle at the end of the curing period.

TABLE 13.—*Relative composition of new and old bacon pickle at establishments A, B, and C.*

ESTABLISHMENT A.

Constituent.	Age of pickle.	Tierce 1, granulated sugar.	Tierce 2, dextrose.	Tierce 3, cerelose.	Tierce 4, 70 per cent corn sugar.	Tierce 5, refiners' sirup.	Tierce 6, raw sugar.
	Days.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Sodium chlorid	New.	100.00	100.00	100.00	100.00	100.00	100.00
Do	26	61.14	61.74	64.49	61.22	62.28	63.21
Sodium nitrate	New.	100.00	100.00	100.00	100.00	100.00	100.00
Do	26	59.18	67.92	66.66	64.15	67.92	67.92
Total sugar	New.	100.00	100.00	100.00	100.00	100.00	100.00
Do	26	76.40	69.32	70.18	70.59	74.58	77.77

ESTABLISHMENT B.

Sodium chlorid	New.	100.00	100.00	100.00	100.00	100.00	.....
Do	45	70.08	71.58	72.98	70.46	70.50	.....
Sodium nitrate	New.	100.00	100.00	100.00	100.00	100.00	.....
Do	45	44.83	59.09	76.92	65.39	79.17	.....
Total sugar	New.	100.00	100.00	100.00	100.00	100.00	.....
Do	45	78.47	86.27	65.69	73.03	76.33	.....

ESTABLISHMENT C.

Sodium chlorid	New.	100.00	100.00	100.00	100.00	100.00	.....
Do	27	55.39	54.59	54.52	55.01	55.92	.....
Sodium nitrate	New.	.....	.....	.....	.....	.....	.....
Do	27	.....	.....	.....	.....	.....	.....
Total sugar	New.	.....	100.00	100.00	100.00	100.00	.....
Do	27	.....	79.27	79.14	70.24	80.90	.....

COMPOSITION OF THE BACON.

Table 14 shows the composition of the several lots of bacon bellies.

TABLE 14.—*Composition of sweet-pickle bacon at establishments A, B, and C.*

ESTABLISHMENT A.

Constituent.	Tierce 1, granulated sugar.	Tierce 2, dextrose.	Tierce 3, cerelose.	Tierce 4, 70 per cent corn sugar.	Tierce 5, refiners' sirup.	Tierce 6, raw sugar.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	15.34	26.04	24.91	17.82	15.68	22.43
Sodium chlorid	3.62	3.15	3.90	2.78	2.36	3.74
Sodium nitrate	.09	.09	.10	.07	.06	.09
Total sugar	.33	.28	.36	.27	.19	.19

ESTABLISHMENT B.

Moisture	19.72	25.73	23.10	23.86	24.37	.....
Sodium chlorid	3.81	4.61	3.88	4.24	4.14	.....
Sodium nitrate	.04	.07	.04	.05	.06	.....
Total sugar	.27	.30	.23	.41	.32	.....

ESTABLISHMENT C.

Moisture	17.51	16.56	16.07	15.88	15.84	.....
Sodium chlorid	2.42	2.98	2.86	2.60	2.46	.....
Sodium nitrate	.05	.06	.05	.05	.05	.....
Total sugar	.16	.18	.16	.11	.35	.....

QUALITY OF THE BACON.

The quality of the bacon was judged upon the basis of the appearance of the freshly cut surface of the meat and of the appearance and palatability of the fried product. The bacon was cut in thin slices, and all lots were fried in as nearly the same manner as possible. Table 15 indicates the relative quality of the several lots of bacon.

At establishment A the basis for scoring was: First choice, 6 points; second choice, 5 points, etc. From the data in Table 15 it is apparent that in the official test the three lots of bacon cured with corn sugars were judged to be of appreciably higher quality than the other lots cured with cane sugars or refiners' sirup. Also, the lot of bacon which ranked highest was the one cured with 70 per cent corn sugar. It was noted that the bacon cured with corn sugars browned more readily on frying than that cured with cane sugar or refiners' sirup. In the plant test at this establishment the results indicate that the bacon cured with cane sugar and refiners' sirup was superior in quality to that cured with the corn sugars. These findings are directly the opposite of those obtained in the official test on the same lots of bacon.

It was noted in the establishment test that the bacon cured with corn sugar had a very dark and burnt appearance after frying. An average of the official and plant tests results in: First choice, tierce 1, granulated sugar, 66 points; second choice, tierce 4, 70 per cent corn sugar, 63 points; third choice, tierce 2, dextrose, 62 points; fourth choice, tierce 3, cerelose, 58 points; fifth choice, tierce 6, raw sugar, 56 points, and sixth choice, tierce 5, refiners' sirup, 53 points.

The basis for scoring at establishments B and C was: First choice, 5 points; second choice, 4 points, etc. The data indicate that at establishment B the bacon cured with dextrose was considered to be of the highest quality, followed in turn by that cured with cerelose, 70 per cent corn sugar, granulated sugar, and refiners' sirup. All lots of bacon at establishment B were considered to be too salty, which is due to the fact that the bellies were held in cure too long, as has been previously noted.

At establishment C the bacon cured with dextrose, cerelose, and refiners' sirup, respectively, was of practically the same quality, while that cured with graulated sugar and 70 per cent corn sugar was of slightly lower quality. On frying, the bacon which had been cured with corn sugar browned nicely while that cured with granulated sugar or refiners' sirup turned yellow.

Establishment C conducted a test on the quality of the sweet-pickle bacon and reported that there was practically no difference in the

flavor of the several lots of bacon but appreciable difference in the appearance of the product on frying. The lots of bacon were ranked in the following order according to the kind of sugar used: First, sirup; second, granulated sugar; third, 70 per cent corn sugar; fourth, cerelose; fifth, dextrose.

TABLE 15.—*Quality of sweet-pickle bacon at establishments A, B, and C.*

ESTABLISHMENT A (OFFICIAL TEST).

Judge.	Tierce 1, granulated sugar.	Tierce 2, dextrose.	Tierce 3, cerelose.	Tierce 4, 70 per cent corn sugar.	Tierce 5, refiners' sirup.	Tierce 6, raw sugar.
	Points.	*Points.*	*Points.*	*Points.*	*Points.*	*Points.*
A	3	4	5	6	1	2
B	3	5	4	6	2	1
C	3	5	4	6	1	2
D	3	5	4	6	2	1
E	3	5	4	6	2	1
F	3	5	4	6	2	1
G	3	4	5	6	1	2
H	3	4	5	6	2	1
I	3	5	4	6	1	2
Total	27	42	39	54	14	13

ESTABLISHMENT A (PLANT TEST).

M	4	3	2	1	5	6
N	5	1	3	2	4	6
O	6	2	3	1	5	4
P	6	3	2	1	4	5
Q	4	3	2	1	5	6
R	6	2	3	1	4	5
S	4	3	2	1	5	6
T	4	3	2	1	6	5
Total	39	20	19	9	38	43

ESTABLISHMENT B.

A	4	5	3	1	2	.....
B	2	5	4	3	1	.....
C	3	5	4	2	1	.....
D	1	3	2	5	4	.....
E	3	5	4	2	1	.....
F	3	5	4	2	1	.....
G	3	5	4	1	2	.....
H	1	5	3	4	2	.....
I	3	5	2	4	1	.....
Total	23	43	30	24	15	.....

ESTABLISHMENT C.

A	2	3	4	1	5	.....
B	4	5	2	1	3	.....
C	1	4	3	5	2	.....
D	2	4	5	1	3	.....
E	5	2	3	4	1	.....
F	2	3	4	1	5	.....
G	1	2	3	4	5	.....
H	3	5	1	2	4	.....
I	1	4	5	3	2	.....
Total	21	32	30	22	30	.....

SUMMARY OF RESULTS OF SWEET-PICKLE BACON EXPERIMENTS.

1. Nineteen tierces of bellies were cured in four establishments.

2. The corn sugars were absorbed as completely by the meat during the process of curing as was the cane sugar.

3. As an average of the results obtained at establishments A, B, and C, it appears that the old pickle from the cured bellies contained 64.57 per cent of the salt, 65.75 per cent of the sodium nitrate, and 75.50 per cent of the sugar originally present in the new pickle. The waste of curing materials occasioned by throwing away the old pickle from sweet-pickle bellies is apparent.

4. No unsound bacon was found in any of the tests.

5. The quality of the bacon cured with the several sugars did not differ widely. As an average of the results of the tests conducted at establishments A, B, and C, it appears that the bacon should be ranked in approximately the following order, according to the kind of sugar used: First, dextrose; second, cerelose; third, 70 per cent corn sugar; fourth, granulated sugar; and, fifth, refiners' sirup.

EXPERIMENTS WITH BOX-CURED BACON.

A large proportion of the fancy breakfast bacon on the market is cured by the so-called "box-cure" method. The bellies cured in this way are especially selected for quality and size and are trimmed to rectangular form. The chilled bellies are packed in specially made metal-lined wooden boxes provided with hinged, tight-fitting covers. The boxes are usually lined with waxed paper before packing with bacon. The bottom is sprinkled with a thin covering of the curing mixture consisting of salt, sugar, and sodium nitrate, and a layer of bacon bellies is then carefully packed on the bottom, flesh side up, and a thin covering of the curing mixture is sprinkled over the meat. Successive layers of bacon and curing mixture are packed until the box is filled. The top layer is finally covered with paper and the cover is fitted into place with the aid of pressure. A definite weight of bacon and curing mixture is packed in each box. The capacity of the boxes used by different establishments varies. Some establishments use boxes holding approximately 625 pounds; others have boxes holding 1,000 pounds. Bacon cured in this way is not overhauled. The curing mixture abstracts moisture from the meat and before the end of the curing period the bellies should be entirely covered with the pickle formed in this way.

PLAN OF WORK.

The experiments with box-cured bacon were carried on at establishments A, B, and C, three boxes of bacon being cured at each plant. Granulated sugar, dextrose, and cerelose were the sugars used. A brief record of the experiments is presented in Table 16.

The same quantities of salt, sodium nitrate, and sugar were used in each box at a single establishment, correction being made for the impurities present in the cerelose. At establishment A the boxes were stored during the curing period in a curing cellar at a temperature of 36°–37° F. The cured bellies were soaked one hour in water at 70° F. and were smoked 30 hours at 130°–135° F. At establishment B the boxes were stored in a curing cellar at a similar temperature and the cured bellies were soaked 10 minutes in water at 70° F. and smoked 18 hours at 100° F. At establishment C the boxes were stored in a curing cellar at a temperature of approximately 40° F. and the cured bellies were soaked one hour in water at 60° F. and were smoked 20 hours at 116° F.

TABLE 16.—*Record of box-cured bacon experiments at establishments A, B, and C.*

ESTABLISHMENT A.

Item.	Box 1, granulated sugar.	Box 2, dextrose.	Box 3, cerelose.
Number of bellies	80	84	83
Curing period.....days	21	21	21
Weight of green bellies.....pounds	625	625	625
Weight of cured bellies.....do	627	630	627
Gain in weight.....do	2	5	2
Condition of smoked bellies	Normal.	Normal.	Normal.

ESTABLISHMENT B.

Number of bellies	46	48	46
Curing period.....days	24	24	24
Weight of green bellies.....pounds	300	300	300
Weight of cured bellies.....do	303	304	305
Gain in weight.....do	3	4	5
Condition of smoked bellies	Normal.	Normal.	Normal.

ESTABLISHMENT C.

Curing period.....days	24	24	24
Weight of green bellies.....pounds	575	575	575
Weight of cured bellies.....do	571	572	572
Loss in weight.....do	4	3	3
Condition of smoked bellies	Normal.	Normal.	Normal.

COMPOSITION OF BOX-CURED BACON.

The composition of the smoked bacon is shown in Table 17. Attention is called to the relatively low salt and high sugar and nitrate content of this bacon at establishment A, as compared with the sweet-pickle bacon cured in the same establishment. (See Table 14.) At establishment B may be noted the relatively high sugar content of the three lots of bacon, the average percentage of sugar being twice as great as that present in the box-cured bacon cured at establishment A, and over eight times as great as the average percentage of sugar present in the sweet-pickle bacon cured at the latter establishment. The figures for establishment C show a low salt and sodium-nitrate con-

tent of this bacon as compared with that cured at establishments A and B. There are considerable differences in the amounts of curing materials present in the three lots of bacon, but these variations do not appear to have any special significance. The average sugar content of the three lots of bacon is 0.55 per cent, as compared with 0.81 per cent in the bacon cured at establishment A, and 1.63 per cent in that cured at establishment B.

TABLE 17.—*Composition of box-cured bacon at establishments A, B, and C.*

Constituent.	Box 1, granulated sugar.	Box 2, dextrose.	Box 3, cerelose.
	Per cent.	*Per cent.*	*Per cent.*
Establishment A.			
Moisture	15.15	13.38	19.93
Sodium chlorid	2.40	1.75	2.46
Sodium nitrate	.20	.13	.16
Total sugar	1.02	.61	.81
Establishment B.			
Moisture	12.23	19.33	14.91
Sodium chlorid	2.46	2.60	2.52
Sodium nitrate	.29	.35	.27
Total sugar	1.82	1.82	1.26
Establishment C.			
Moisture	14.67	14.34	12.68
Sodium chlorid	1.77	.96	1.16
Sodium nitrate	.12	.03	.09
Total sugar	.77	.33	.56

QUALITY OF BOX-CURED BACON.

The relative quality of the bacon is shown in Table 18, the test being made in the manner previously described. The basis for scoring was: First choice, 3 points; second choice, 2 points, etc.

TABLE 18.—*Quality of box-cured bacon at establishments A, B, and C.*

Judge.	Establishment A (Official test).			Judge.	Establishment A (Plant test).		
	Box 1, granulated sugar.	Box 2, dextrose.	Box 3, cerelose.		Box 1, granulated sugar.	Box 2, dextrose.	Box 3, cerelose.
	Points.	*Points.*	*Points.*		*Points.*	*Points.*	*Points.*
A	1	3	2	M	3	1	2
B	1	2	3	N	3	1	2
C	1	3	2	O	3	1	2
D	2	3	1	P	3	1	2
E	3	1	2	Q	3	1	2
F	1	2	3	R	3	2	1
G	1	3	2	S	3	1	2
H	3	2	1	T	3	1	2
Total	13	19	16	Total	24	9	15

TABLE 18.—*Quality of box-cured bacon at establishments A, B, and C*—Contd.

Judge.	Establishment B.			Judge.	Establishment C.		
	Box 1, granulated sugar.	Box 2, dextrose.	Box 3, cerelose.		Box 1, granulated sugar.	Box 2, dextrose.	Box 3, cerelose.
	Points.	*Points.*	*Points.*		*Points.*	*Points.*	*Points.*
A	3	2	1	A	3	2	1
B	1	3	2	B	1	3	2
C	3	1	2	C	2	3	1
D	3	2	1	D	3	2	1
E	1	3	2	E	2	1	3
F	2	3	1	F	3	2	1
G	1	2	3	G	2	1	3
H	3	2	1	H	1	3	2
I	2	3	1	I	3	2	1
J	1	2	3	J	2	3	1
Total	20	23	17	Total	22	22	16

The results of the official test at establishment A indicate that when carefully broiled or fried the bacon cured with granulated sugar turned golden yellow in color—that is, the fatty tissue—while that cured with dextrose and cerelose turned light brown. Choice on the basis of appearance was largely a matter of personal taste. When fried too rapidly or too crisp, the bacon cured with the corn sugar had a tendency to turn dark-brown or to char. Under such conditions the bacon cured with granulated sugar was to be preferred. There was only a comparatively slight difference in the quality of the three lots of bacon, that cured with dextrose ranking first, with cerelose second, and with granulated sugar third.

In the plant test at establishment A the bacon cured with cane sugar was much preferred, particularly because it turned golden yellow in color on frying, whereas the bacon cured with corn sugars fried brown in color and charred readily. The officials stated that the bacon cured with dextrose and cerelose would not prove satisfactory on the market in competition with bacon cured with cane sugar.

The scoring of the bacon cured at establishment B indicates that there was very little difference in the quality of the three lots of bacon. As has been noted, the bacon cured with dextrose and cerelose browned more readily on frying or broiling than that cured with granulated sugar. There seemed to be very little difference in the flavor of the three lots of bacon, all being of high quality.

The results for establishment C show that the bacon cured with granulated sugar and that cured with dextrose were of practically the same quality, while that cured with cerelose was of only slightly lower quality. The bacon cured with corn sugar turned light brown on cooking, while that cured with granulated sugar turned yellow. All the bacon was considered to be of first-class quality.

The officials of establishment C conducted a cooking test on the three lots of bacon and reported that the samples were ranked as follows, according to the kind of sugar used in curing: First choice, granulated sugar; second choice, dextrose; third choice, cerelose. The bacon cured with corn sugar had a tendency to char on frying, while that cured with granulated sugar turned yellow. There seemed to be but little difference in flavor. It was considered that the use of corn sugar in place of cane sugar in curing this class of bacon would not yield a satisfactory bacon on account of the tendency of the product to turn brown or char on frying.

SUMMARY OF RESULTS OF BOX-CURED BACON EXPERIMENTS.

1. Nine boxes of bacon were cured in three establishments.

2. The average sugar content of the bacon cured with each of the three sugars was as follows: Granulated sugar, 1.20 per cent; dextrose, 0.92 per cent; cerelose, 0.88 per cent. This indicates a slightly greater absorption of granulated sugar than of corn sugar.

3. No unsound bacon was found in any of the tests.

4. The evidence as to the relative quality of the bacon cured with granulated sugar, dextrose, and cerelose is conflicting. A summary of the three tests conducted in the laboratory shows that the total number of points scored by each lot of bacon was as follows: Dextrose, 64; granulated sugar, 55; and cerelose, 49. All lots of bacon were considered to be of high quality. On the other hand, the tests conducted by officials of establishments A and C indicated a marked preference for the bacon cured with granulated sugar, that cured with dextrose ranking second, and with cerelose third. Objection was made to the bacon cured with corn sugar chiefly because the product browned too readily on frying and charred if cooked too rapidly or too crisp. It was considered that bacon cured with corn sugar by the box method would not be so desirable a product as that cured with granulated sugar.

The writer is of the opinion, notwithstanding these conflicting views, that the possibility that corn sugars can be used successfully in curing bacon by the box-cure method is not excluded, but that further experiments should be carried on in order to settle the question.

EXPERIMENTS WITH BEEF HAMS.

Beef hams are groups of muscles cut from the rounds of cattle. The hams are classed as insides, outsides, and knuckles, according to the part of the round from which they are cut. Beef hams are usually cut from the rounds of poorly finished medium or lightweight cattle. The hams are packed in tierces and cured in a pickle containing salt, sugar, and sodium nitrate. When cured the hams are soaked in water to remove excess salt and are then smoked and dried for several days. The dried-beef hams are finally cut into very thin slices, either at the packing house or in the retail meat shop,

before being sold to the consumer, who purchases the product as "chipped beef." High-grade "chipped beef" should be bright red in color, mildly salty, sweet, and of pleasing flavor. When properly cured, dried beef, either in the ham or chipped, should keep in good condition for a considerable time at ordinary temperatures.

PLAN OF WORK.

The experimental work was conducted at establishments A and B, five tierces of hams being cured at each plant. Granulated sugar, dextrose, cerelose, 70 per cent corn sugar, and refiners' sirup were the sugars used. The hams were cured according to the usual practice at each establishment except as regards the kind of sugar used. One tierce of hams was cured in pickle made up according to the formula regularly followed in the establishment, while each of the other tierces of hams was cured in pickle of like composition except that an equivalent amount of corn sugar, or of the sugar found in refiners' sirup, was substituted for the sugar regularly used.

The chilled beef hams ("insides") were packed in tierces which were then filled with pickle, but at establishment B 5 pounds of salt was sprinkled over the hams in each tierce when packed, and the tierce was then filled with pickle. The tierces were stored in a curing cellar at approximately 37° F. and were rolled on the fifth, fifteenth, and thirtieth days after packing. At establishment A the cured hams were soaked 9 hours in water at 70° F. and were smoked 6 days at 135° F. At establishment B the cured hams were soaked 20 hours in two changes of water at 65° F. with four overhaulings. The hams were smoked and dried five days at a temperature of 100°–110° F.

The smoked hams were inspected for soundness by a Government inspector. Two hams from each tierce were selected for test purposes. A brief record of the experiment is presented in Table 19.

TABLE 19.—*Record of beef-ham experiments at establishments A and B.*

ESTABLISHMENT A.

Item.	Tierce 1, granulated sugar.	Tierce 2, dextrose.	Tierce 3, cerelose.	Tierce 4, 70 per cent corn sugar.	Tierce 5, refiners' sirup.
Number of hams	29	27	27	27	27
Weight of green hams.....pounds..	330	330	330	330	320
Weight of cured hams.....do....	362	355	375	374	354
Gain in weight.....do ...	32	25	45	44	34
Quantity of pickle.....gallons..	13	13	12½	15	17¾
Condition of smoked hams.....	Normal.	Normal.	Normal.	One light sour.	One light sour.

ESTABLISHMENT B.

Number of hams	27	27	27	27	27
Weight of green hams.....pounds..	320	320	320	320	320
Quality of pickle.....gallons..	15	14	15	16	15
Condition of smoked hams.....	Normal.	Normal.	Normal.	Normal.	Normal.

The composition of the new and old pickle from each tierce is shown in Table 20.

TABLE 20.—*Composition of beef-ham pickle at establishments A and B.*

ESTABLISHMENT A.

Tierce No.	Age of pickle.	Kind of sugar.	Specific gravity at 20° C.	Salometer reading at 20° C.	Sodium chlorid.	Sodium nitrate.	Total sugar.
	Days.			*Degrees.*	*Per cent.*	*Per cent.*	*Per cent.*
1	New.	Granulated	1.190	94	23.10	0.67	1.58
1	90	.....do	1.082	42	8.52	.35	1.04
2	New.	Dextrose	1.190	94	23.15	.66	1.45
2	90	.....do	1.081	42	8.36	.....	.89
3	New.	Cerelose	1.190	94	23.15	.69	1.54
3	90	.....do	1.080	42	8.23	.34	.70
4	New.	70 per cent corn sugar	1.190	94	23.00	.69	1.66
4	90	.....do	1.087	44	9.07	.39	.85
5	New.	Refiners' sirup	1.193	95	22.90	.67	1.50
5	90	.....do	1.090	49	10.03	.39	1.07

ESTABLISHMENT B.

1	New.	Granulated	1.191	95	22.28	0.92	2.59
1	72	.....do	1.098	50	9.65	.31	.91
2	New.	Dextrose	1.200	98	23.75	.77	2.17
2	72	.....do	1.095	49	10.19	.21	.75
3	New.	Cerelose	1.200	98	23.54	.77	2.20
3	72	.....do	1.083	43	8.37	.18	.17
4	New.	70 per cent corn sugar	1.200	98	23.28	.81	2.65
4	72	.....do	1.104	53	11.32	.20	1.13
5	New.	Refiners' sirup	1.198	97	23.86	.78	2.51
5	72	.....do	1.100	49	10.34	.22	.64

Table 21 indicates the relative composition of the new and old pickle from each tierce based upon 100 parts of each constituent in the new pickle.

At establishment A it appears that relatively the smallest proportion of sugar in the form of cerelose remained in the old pickle from the cured hams, and the highest proportion of sugar from refiners' sirup. As an average of the data for each constituent remaining in the old pickle it appears that 38.35 per cent of the salt, 54.06 per cent of the sodium nitrate and 59.05 per cent of the sugar originally present in the new pickle was found in the old pickle.

In the consideration of the figures for sodium chlorid at establishment B it is to be remembered that 5 pounds of salt was added to each tierce of beef hams in addition to the salt present in the new pickle. The relative percentage of salt in the old pickle as compared with the new pickle does not, on this account, represent the true proportion of the salt, added to the fresh hams in dry form and in pickle, which remains in the old pickle.

TABLE 21.—*Relative composition of new and old beef-ham pickle at establishments A and B.*

ESTABLISHMENT A.

Constituent.	Age of pickle.	Tierce 1, granulated sugar.	Tierce 2, dextrose.	Tierce 3, cerelose.	Tierce 4, 70 per cent corn sugar.	Tierce 5, refiners' sirup.
	Days.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Sodium chlorid	New.	100.0	100.00	100.00	100.00	100.00
Do	90	36.88	36.11	35.55	39.43	43.80
Sodium nitrate	New.	100.00	100.00	100.00	100.00	100.00
Do	90	52.24	.....	49.28	56.52	58.21
Total sugar	New.	100.00	100.00	100.00	100.00	100.00
Do	90	65.82	61.38	45.55	51.20	71.33
ESTABLISHMENT B.						
Sodium chlorid	New.	100.00	100.00	100.00	100.00	100.00
Do	72	43.31	42.90	35.56	48.62	45.23
Sodium nitrate	New.	100.00	100.00	100.00	100.00	100.00
Do	72	33.69	27.30	23.37	24.69	28.21
Total sugar	New.	100.00	100.00	100.00	100.00	100.00
Do	72	31.27	34.56	7.73	42.64	25.50

COMPOSITION OF BEEF HAMS.

The composition of the dried and smoked beef hams is indicated in Table 22. Analyses were made of sections cut from the middle of each of two hams from each tierce. There are appreciable differences in the percentages of salt, sodium nitrate, and sugar present in the several lots of hams, but the significance of the figures is not apparent.

It may be noted that the sugar content of the hams cured with dextrose is appreciably lower, and that of the hams cured with cerelose very much lower than that of the other lots of hams. The evidence is not sufficient to allow any conclusion to be drawn. The sodium-nitrate content of the beef hams cured with granulated sugar and with dextrose is considerably lower than that of the other lots of hams.

TABLE 22.—*Composition of beef hams at establishments A and B.*

ESTABLISHMENT A.

Constituent.	Tierce 1, granulated sugar.	Tierce 2, dextrose.	Tierce 3, cerelose.	Tierce 4, 70 per cent corn sugar.	Tierce 5, refiners' sirup.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	59.26	55.82	57.67	52.67	57.07
Sodium chlorid	8.26	8.74	9.02	9.15	9.73
Sodium nitrate	.19	.23	.36	.39	.34
Total sugar	.50	.33	.28	.49	.59
ESTABLISHMENT B.					
Moisture	53.29	54.96	55.38	53.63	52.76
Sodium chlorid	9.14	10.60	8.40	10.16	10.35
Sodium nitrate	.04	.04	.11	.19	.18
Total sugar	.69	.52	.11	.70	.79

QUALITY OF DRIED-BEEF HAMS.

The quality of the dried beef was judged from the appearance and palatability of thin slices of the beef cut from the middle portion of

each of two hams from each tierce. The dried beef was eaten without cooking. A report of the tests is shown in Table 23.

The result of this test at establishment A indicates that the beef hams cured with dextrose were of the highest quality, followed in turn by those cured with cerelose, granulated sugar, 70 per cent corn sugar, and refiners' sirup. Granulated sugar was being used regularly in curing beef hams at this establishment, and this grade of sugar is very generally used in curing beef hams. Thus it appears that the hams cured with two of the corn sugars, namely, dextrose and cerelose, were superior in quality to the hams cured with granulated sugar.

The results at establishment B indicate that the beef hams cured with granulated sugar were of the highest quality, closely followed by those cured with cerelose; the beef hams cured with dextrose and with 70 per cent corn sugar were of practically the same but of appreciably lower quality than those cured with either granulated sugar or cerelose, while the hams cured with refiners' sirup were of a decidedly lower quality, both as regards appearance and flavor.

TABLE 23.—*Quality of dried-beef hams at establishments A and B.*

ESTABLISHMENT A.

Judge.	Tierce 1, granulated sugar.	Tierce 2, dextrose.	Tierce 3, cerelose.	Tierce 4, 70 per cent corn sugar.	Tierce 5, refiners' sirup.
	Points.	*Points.*	*Points.*	*Points.*	*Points.*
A	5	1	4	2	3
B	2	5	4	3	1
C	3	5	4	1	2
D	1	4	5	2	3
E	1	5	2	4	3
F	3	5	4	2	1
G	3	5	4	2	1
H	4	5	3	2	1
Total	22	35	30	18	15

ESTABLISHMENT B.

A	5	3	2	4	1
B	3	1	5	4	2
C	5	2	4	3	1
D	4	3	5	2	1
E	5	2	4	3	1
F	4	5	3	2	1
G	5	2	4	3	1
H	4	3	5	2	1
I	2	5	3	4	1
Total	37	26	35	27	10

SUMMARY OF RESULTS OF CURING EXPERIMENTS WITH BEEF HAMS.

1. Ten tierces of beef hams were cured at two establishments.

2. Only one slightly sour beef ham was found in the two experiments, and that in a tierce cured with refiners' sirup.

3. Combining the results of the tests on the quality of the beef hams cured at the two establishments, the several lots of hams rank as follows according to the kind of sugar used: First choice, cerelose, 65 points; second choice, dextrose, 61 points; third choice, granulated sugar, 59 points; fourth choice, 70 per cent corn sugar, 45 points; fifth choice, refiners' sirup, 35 points. These facts indicate that dextrose and cerelose are at least equal in value to granulated sugar for use in curing beef hams, but refiners' sirup yielded a product of lower quality.

GENERAL SUMMARY.

1. The results of the experiments in curing pork hams indicate that the several sugar substitutes employed, viz, dextrose, cerelose, 70 per cent corn sugar, and refiners' sirup, can be used successfully in place of cane sugar in curing this class of meats. The difference in the quality of the hams cured with the several sugars was slight.

2. The results obtained in the curing of sweet-pickle bacon with the sugar substitutes named, as compared with cane sugar, were similar to those obtained with pork hams. There was comparatively little difference in the quality of the bacon cured with the different sugars. However, the bacon cured with the three corn sugars was considered to be of slightly better quality than that cured with cane sugar or refiners' sirup.

3. The experiments with box-cured bacon yielded conflicting results. The tests on the quality of the bacon conducted by the department indicated that there was little difference in the quality of the bacon cured with dextrose and cerelose as compared with that cured with cane sugar. On the other hand, the tests conducted by two of the establishments indicated that bacon cured with cane sugar was of distinctly superior quality, chiefly because the bacon cured with corn sugars browned too readily on frying. In view of these conflicting opinions, further experiments in the use of corn sugars in curing box-cured bacon are desirable.

4. In the curing experiments with beef hams, the use of dextrose and cerelose yielded dried beef of as good quality as that obtained by the use of cane sugar. The beef hams cured with 70 per cent corn sugar and with refiners' sirup were of inferior quality.

5. The experiments reported in this paper must be regarded as of a preliminary nature, and while the results indicate strongly that several corn sugars, as well as refiners' sirup, can be used successfully as substitutes for cane sugar (sucrose) in curing meats, yet it is highly advisable that meat-packing establishments contemplating the use of one or more of these substitutes first conduct curing tests on a moderate scale before curing large quantities of meat with the sugar substitutes chosen.

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